Product User Manual

♦

Process Control System
for
GA4307 Microwave Generator

Document # 930048, Rev. 1

GERLING

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REVISION HISTORY			
REV.	**DESCRIPTION**	**DATE**	**APPROVAL**
1	PROTOTYPE RELEASE	27MAR04	JFG

WARRANTY

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This warranty supercedes all other warranties, expressed or implied. No warranty is given covering the product for any particular purpose other than as covered by the applicable product specifications. GAE assumes no liability in any event for incidental or consequential damages, financial losses, penalties or other losses incurred in conjunction with the use of GAE products.

DOCUMENT CONVENTIONS

NOTE: *Means the reader should take note. Notes contain helpful information, suggestions, or references to other sections, chapters, or documents.*

CAUTION: *Means the reader should be careful. You are doing something that might result in equipment damage or loss of data.*

WARNING: *Means danger. A situation exists that could cause bodily injury or death. All personnel must be aware of the hazards involved with high voltage electrical circuitry and high power microwave devices.*

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WARNING

All microwave generators manufactured by GAE, Inc. are capable of producing a microwave field that is potentially hazardous to operating personnel. They must never be connected or operated in a manner that allows a field in excess of 10 milliwatts per square centimeter to be generated in an area accessible to operating personnel. Contact GAE, Inc. for technical support prior to installation and/or operation of these units if there is any question or concern about microwave leakage.

All waveguide flange and electrical cable connections throughout the system must be secure prior to operation. Never operate the microwave generator without a properly rated absorbing load attached. To ensure safe operation and prevent microwave leakage, the equipment must be periodically inspected and maintained as required or recommended.

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EQUIPMENT DESCRIPTION

The Process Control System (PCS) described in this manual is designed for use with the GA4307 microwave generator for simple PID control of process temperature. The PCS reads an analog input signal from a thermocouple sensor that detects the temperature of a material being heated by microwave energy generated by the GA4307 and controls the output power level of the GA4307 by means of an analog output voltage signal.

The PCS is a laptop computer based system with National Instruments peripheral hardware and customized PID control software. Functional controls provided in the software include microwave start/stop buttons, user adjustment of the temperature control setpoint, and user-adjustable PID loop parameters to provided flexibility in fine-tuning specific processes. A detailed explanation of the control software is provided in a separate instruction manual accompanying this document.

General Specifications

Computer	Dell Latitude D600 Laptop with MS-Windows XP
I/O Interface	National Instruments DAQCard-6023E
Software	Custom PID control software
Analog Input	Type K thermocouple
Analog Output	0-10 VDC
Digital Output	Two dry contact relays wired NO and NC
Controls	Mw Start (NO relay contact) Mw Stop (NC relay contact) Process temperature setpoint PID loop parameters
Line Power	100-240 VAC, 50/60 Hz, 2.5 Amps
Connectors	9-pin male D-sub

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Components Supplied

Item Description	Mfr	Part Number
Computer	Dell (includes power supply and mouse)	Latitude D600
I/O Interface	National Inst.	DAQCard-6023E
Signal Conditioning Connector Block	National Inst. (includes power supply)	SC-2345
Analog Input Module	National Inst.	SCC-TC02
Analog Output Module	National Inst.	SCC-AO10
Digital Output Module	National Inst.	SCC-RLY01 (2 ea.)
Interconnect Cable	National Inst.	1868386-01
Product User Manual	GAE (this document)	930048

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INSTALLATION

Preliminary Inspection

Upon arrival at the installation site the PCS system components should be thoroughly inspected for damage or wear caused during shipping. Any visible damage to the packaging material or the equipment itself should be noted and reported immediately to the shipping company in accordance with standard claims procedures.

Module Installation

The PCS is intended for use in a clean dry environment, such as a laboratory or cleanroom, or anywhere a typical laptop computer can be used. The individual system components can be installed in any orientation that is convenient for connection to the magnetron head and a source of line power.

Interconnect Cables

All cables required for interconnection between PCS system components and the magnetron head are provided. Figure 1 is a block diagram of the PCS illustrating the component interconnections.

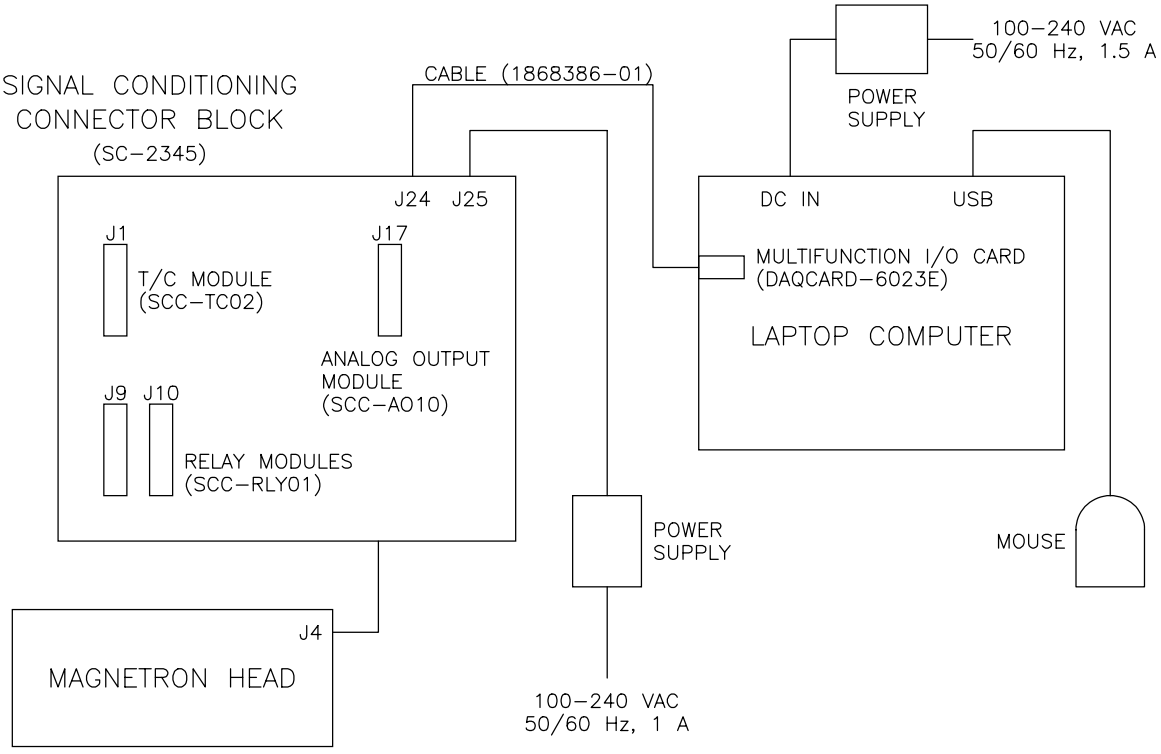

Figure 1. Block diagram of the Process Control System.

Line Power Connection

Line power connections to standard three-prong 115 VAC outlet receptacles are required for the Signal Conditioning Connector Block (SCCB) and Laptop Computer as shown in Figure 1. Grounded receptacles must be used for regulatory safety compliance.

Control Wiring Connections

Figure 2 below illustrates the wiring connections between the PCS and GA4307 microwave generator (magnetron head). A wiring harness with the 9-pin D-sub connector is provided with the PCS.

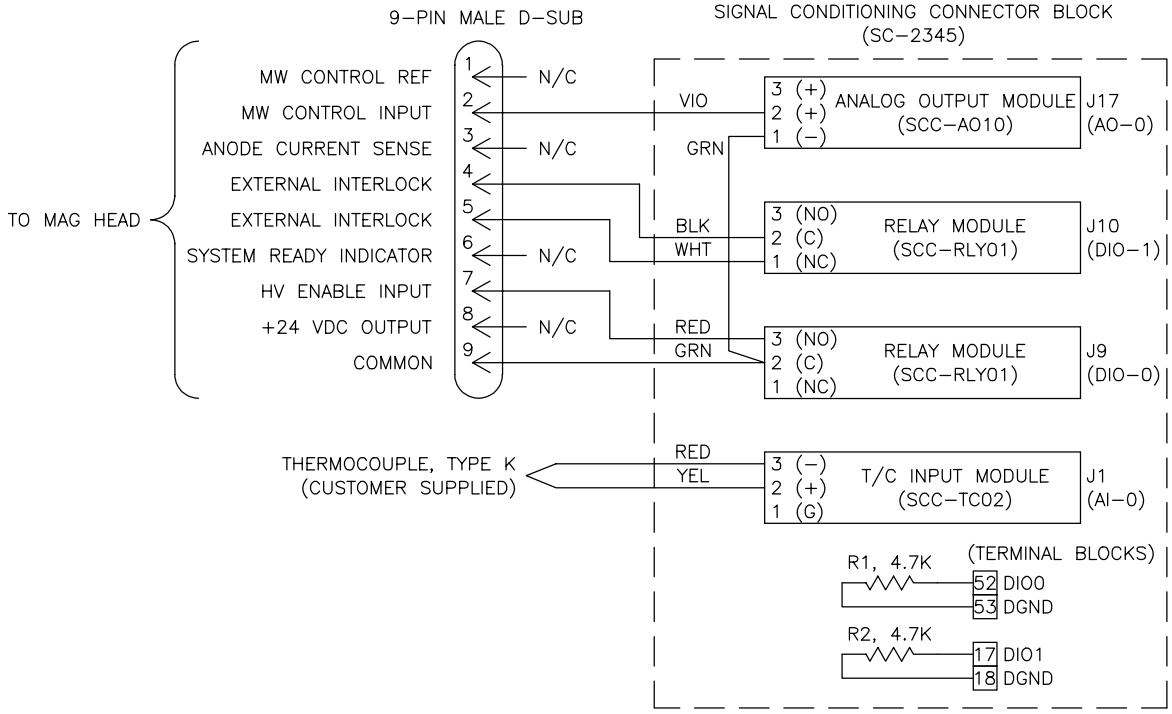

Figure 2. Wiring connections between the SCCB and GA4307 microwave generator.

Thermocouple Connection

Figure 2 above shows connection of a customer-supplied Type K thermocouple to the T/C input module located at position J1 in the SCCB.

NOTE: *Other thermocouple types may also be used. However, this requires a change to the hardware set-up configuration. See the NI-DAQ user manual(s) for more information on changing the hardware set-up parameters.*

BASIC OPERATION

The PCS operates the microwave generator by a) providing basic manually operated on-off control of microwave power, b) automatic PID control of the microwave output power level to maintain a process setpoint temperature, and c) manual control of microwave output power while bypassing the PID control loop. All control functionality is accessed within a customized software environment on a laptop computer.

Start-up and Shut-down

The following basic procedure may be used as a guideline for start-up and shut-down of the PCS. Alterations to this procedure may be necessary to accommodate standard shop/lab procedures and/or other operational requirements.

1. Connect the PCS and microwave generator to their respective sources of line power.

NOTE: *The SCCB does not have a power switch. It will be operational upon connecting line power.*

2. Turn on the microwave generator by actuating the main power switch located on the side of the power supply.
3. Set the toggle switch located on the magnetron head front panel to “Remote” to allow the PCS to control the microwave output power level.
4. Turn on the laptop computer by pressing the power button below the display screen. Log into MS-Windows® and allow the computer to reach a steady state of operation.
5. Turn on the PCS software application as follows:
    a. Double-click the “GAE” icon located on the MS-Windows® desktop.
    b. Refer to the next section for detailed instructions on software operation and system control.
6. Any of the following actions will safety stop the PCS from operating without causing damage to the system:
    a. Click EXIT to terminate PCS software operation.
    b. Turn off the laptop computer.
    c. Unplug the SC-2345 Signal Conditioning Chassis. Note that this action will not stop the PCS software application from operating.

WARNING: *Stopping the PCS from operating will not necessarily stop microwave power from being generated. See below for information and procedures to safely turn off microwave power.*

7. Microwave power can be turned off by any of the following operations:
    a. Click the MICROWAVE POWER ON – PRESS TO TURN MICROWAVE OFF button on the PCS main data collection screen.
    b. Press the MW STOP button on the front panel of the magnetron head.
    c. Disconnect line power from the GA4307 microwave generator.

CONTROL SOFTWARE

The PCS software program is specifically designed for use with the model GA4307 microwave generator and custom process control system. The program utilizes internal databases and communicates with the SCC family of hardware modules manufactured by National Instruments to form an integrated system that automatically controls the microwave power according to the temperature set point.

Basic Software Functions

The PC coordinates the activity of all the components in the overall system using the following control functions:

- A unique data collection file is created each time the program is started.
- The operator can start and stop the data collection and microwave generator.
- The program displays and records each new sampled data point for display and archiving.
- The temperature control response can be fine tuned by adjusting the PID control parameters.
- Previous data files can be recalled and displayed.

Launching the Program

The software program is launched by selecting the “GAE” icon from the main desktop screen as shown below.

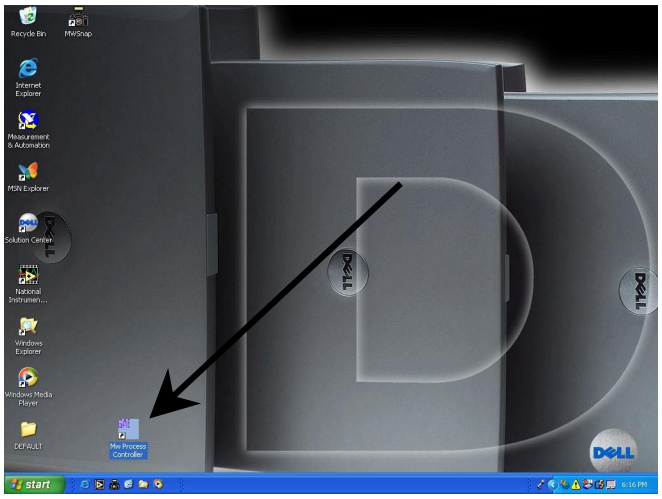

Figure 3. Windows desktop showing the PCS software icon.

Logon Screen

The logon screen appears after the program finishes loading. To progress from this screen, a correct security operator identification and associated password must be entered.

The logon screen:

- Provides access to the system, program engineering, and/or configuration screens if an engineering level identification and associated password are entered.
- Allows normal operation access to the program if any correct operator identification and associated password are entered.

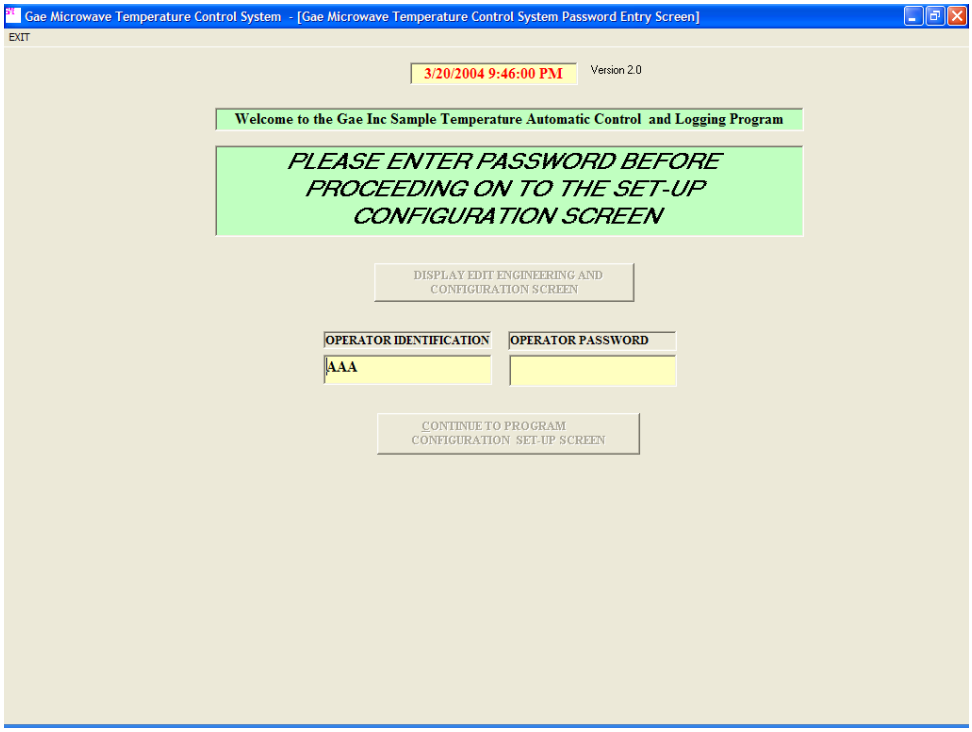
Gae Microwave Temperature Control System - [Gae Microwave Temperature Control System Password Entry Screen]
EXIT
3/20/2004 9:46:00 PM
Version 2.0
Welcome to the Gae Inc Sample Temperature Automatic Control and Logging Program
PLEASE ENTER PASSWORD BEFORE PROCEEDING ON TO THE SET-UP CONFIGURATION SCREEN
DISPLAY EDIT ENGINEERING AND CONFIGURATION SCREEN
OPERATOR IDENTIFICATION
OPERATOR PASSWORD
AAA
CONTINUE TO PROGRAM CONFIGURATION SET-UP SCREEN

Figure 4. The logon screen.

Logon Screen Invalid Operator Entry

The operator or supervisor must enter a valid name and password in order to operate the program. Valid identification names are configured using the “Engineering and Configuration” screen (see next section). Valid operator names must be set-up by a supervisor who has been granted access to the system configuration screens.

If an invalid operator name is entered, an “Invalid Operator” entry pop-up screen will be displayed.

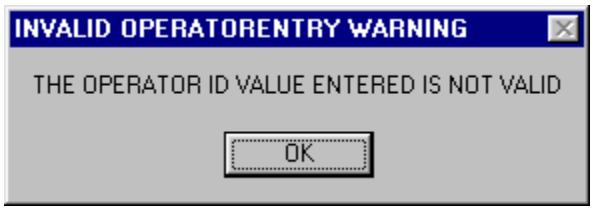

Figure 5. Pressing [OK] on this screen will return you to the Main screen.

NOTE: *Operator Identification entries are case sensitive and must match one of the configured operator names.*

Logon Screen Invalid Password Entry

Each valid operator, supervisor, or engineer name has an associated password that must be entered in order to operate the program. Valid operator identification passwords are configured from the “Engineering and Configuration” screen. An engineer who has access to the system configuration screens must set up operator passwords.

If an invalid operator name is entered, a pop-up screen will be displayed to warn that an incorrect name has been entered.

Figure 6. Pressing [OK] on this screen will return you to the Main screen.

NOTE: *Password entries are case sensitive and must match one of the configured operator passwords.*

Logon Screen Operator Level Identification and Password

After entering a valid operator name and password (default values are “AAA” and “12345”), a button below the password entry area becomes active. The entry fields will become green to indicate that the security level is set for operator control only.

Gae Microwave Temperature Control System - [Gae Microwave Temperature Control System Password Entry Screen]
EXIT
Close
3/20/2004 9:46:15 PM
Version 2.0
Welcome to the Gae Inc Sample Temperature Automatic Control and Logging Program
PLEASE ENTER PASSWORD BEFORE PROCEEDING ON TO THE SET-UP CONFIGURATION SCREEN
DISPLAY EDIT ENGINEERING AND CONFIGURATION SCREEN
OPERATOR IDENTIFICATION
OPERATOR PASSWORD
AAA
*****
CONTINUE TO PROGRAM CONFIGURATION SET-UP SCREEN

Figure 7. Main screen after entry of valid operator name and password.

Main Screen Supervisor Level Identification and Password

After entering a valid supervisor level name and password (default values are “GAE” and “GAE”), a button below the password entry area becomes active. Double-clicking this button will open the Configuration Set Up Screen.

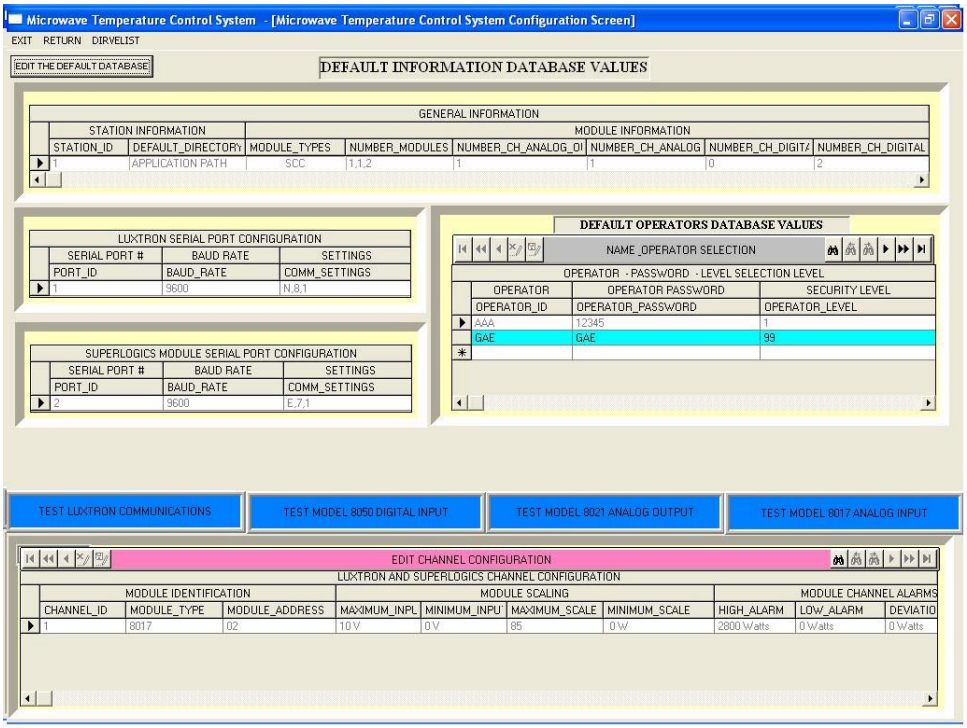

Figure 8. Configuration screen after entry of valid supervisor name and password.

Most of the information displayed in the Configuration screen is provided for non-user and/or optional program functionality. The primary task allowed for the is the entry and editing of operator usernames and passwords.

Operator ID – Any alpha-numeric value (case-sensitive)

Operator Password – Any alpha-numeric value (case-sensitive)

Security Level – Use “1” for all operators and “99” for all supervisors.

Exiting the Program from the Logon Screen

An operator has the option to exit the program from the main screen by selecting the “Exit” button from the menu selector located in the upper left corner of the screen.

Data File Set-Up Screen

Set-Up Screen File Selection

The screen will appear and will contain a data file name entry box where a unique file name must be entered. After the desired transaction file name has been entered, the <TAB> button must be pressed to accept the entry. The file name entered must be unique and less than 12 characters long. No file name extension (i.e. .doc, .txt) is required. If the file name already exists, it can be optionally concatenated with {_1 through _99} if desired by the operator. The operator should choose names that will be easy to identify and have some meaning—for example:

sampledata_1a

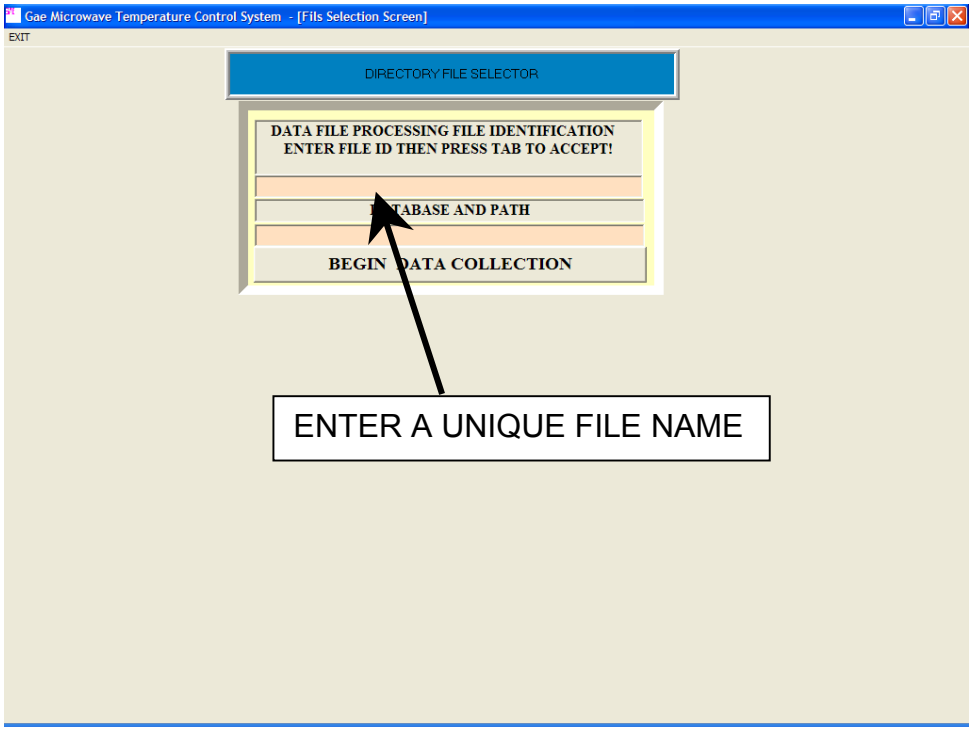
Gae Microwave Temperature Control System - [Fils Selection Screen]
EXIT
DIRECTORY FILE SELECTOR
DATA FILE PROCESSING FILE IDENTIFICATION
ENTER FILE ID THEN PRESS TAB TO ACCEPT!
ENTER A UNIQUE FILE NAME

Figure 9. Set-Up screen entry of the unique data file name.

Set-Up Screen – Check the File Name

The file name is checked to insure that it is no longer then 12 characters long. If the file name exceeds 12 characters, an error box will appear advising that the file name has been automatically truncated to 12 digits.

Figure 10. Set-up screen: File name more than 12 digits warning.

The file name must be unique and each transaction file that is entered will be checked against all of the other file names in the directory to ensure that no duplicate file exists. If a duplicate file is detected, a warning pop-up message will give the operator the opportunity to enter another new and unique transaction file name.

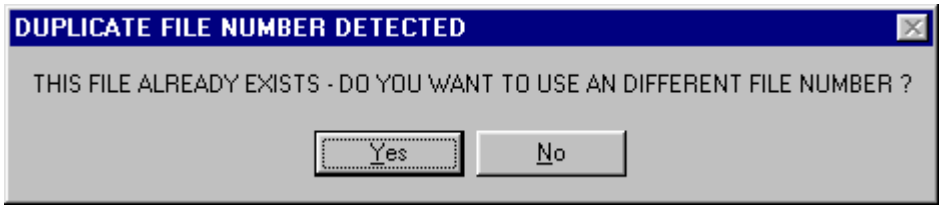

Figure 11. Set-up screen: Duplicate file name decision.

If the “Yes” from Figure 11 is selected then the original entry file pop-up screen appears and a unique file name should be entered.

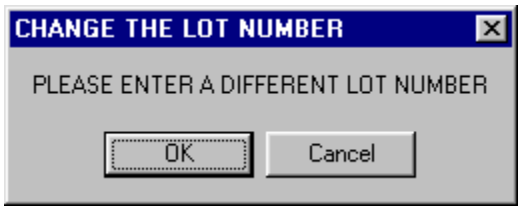

Figure 12. Set-up screen: Enter another new file name.

If the “No” from Figure 11 is selected, then the file name entered will be concatenated with a sequential suffix to automatically create a unique file name.

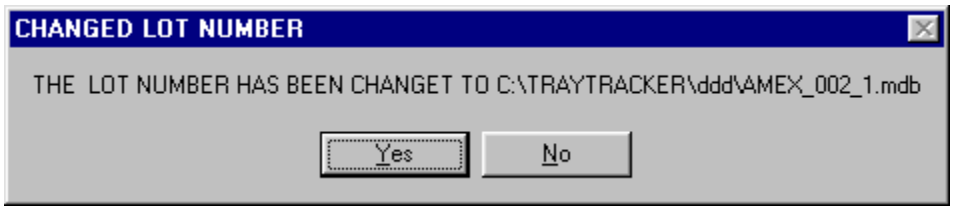

Figure 13. Set-up screen: File transaction concatenated message.

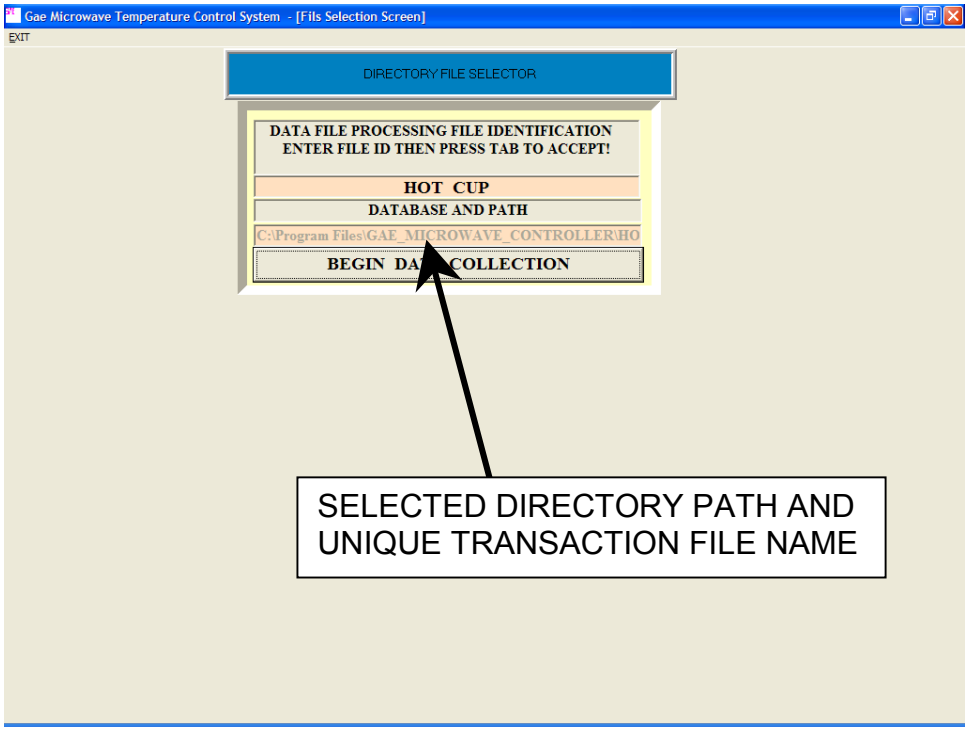
Gae Microwave Temperature Control System - [Fils Selection Screen]
EXIT
DIRECTORY FILE SELECTOR
DATA FILE PROCESSING FILE IDENTIFICATION
ENTER FILE ID THEN PRESS TAB TO ACCEPT!
HOT CUP
DATABASE AND PATH
C:\Program Files\GAE_MICROWAVE_CONTROLLER\HO
BEGIN DA COLLECTION
SELECTED DIRECTORY PATH AND
UNIQUE TRANSACTION FILE NAME

Figure 14. Set-up screen after the unique file name has been successfully entered.

After pressing the “Begin Data Collection” button the Data Collection screen will appear.

Data Collection Screen

After the set-up is complete and a unique file name has been entered, the Data Collection screen (Figure 15) will be displayed. The Data Collection screen will remain visible until the program is shut down or another data collection file is selected.

Main Data Indicators

The Data Collection screen has the displays and status indicators necessary to monitor all aspects of the microwave control and data collection system.

- Digital indicators will continuously display the set point, current temperature, error from set point and the current elapsed time.
- The control mode “Manual” or “Auto” will show with a green or red background color indictor.
- The microwave generator “On” or “Off” will show with a green or red background color indictor.
- The chart located below the display indicators shows a real-time record of either current temperature or temperature error throughout the process cycle.

The TEMPERATURE DATA COLLECTION HISTORY grid located below the indicator panels will display the data collection processing history. Selecting the any of the column table header row will automatically sort the complete database in ascending order using based on the column selected.

The output control voltage and input temperature signals along with the current setpoint value can be shown in a slider type display (Figure 16) by clicking the PID LOOP DISPLAY button located in the upper left corner.

Basic Operator Controls

Located above the display indicators are buttons for manually turning on and off the microwave generator and data collection.

- The microwave generator can be started by clicking on the red MICROWAVE POWER OFF – PRESS TO TURN MICROWAVE ON button. This button will then change to green and read MICROWAVE POWER ON – PRESS TO TURN MICROWAVE OFF. Microwave power can be toggled on and off by simply clicking this button.
- Data collection can be started or stopped by clicking on the DATA COLLECT button. This button will be red and read OFF when data collection is off, and it will be green and read ON when data is being collected.

- The screen can be exited by clicking on the NEW LOG FILE SET-UP button located on the upper right corner of the screen. After selecting the button, the Set-up screen will be displayed again.
- The program can be exited by clicking the EXIT button in the upper left corner of the screen.

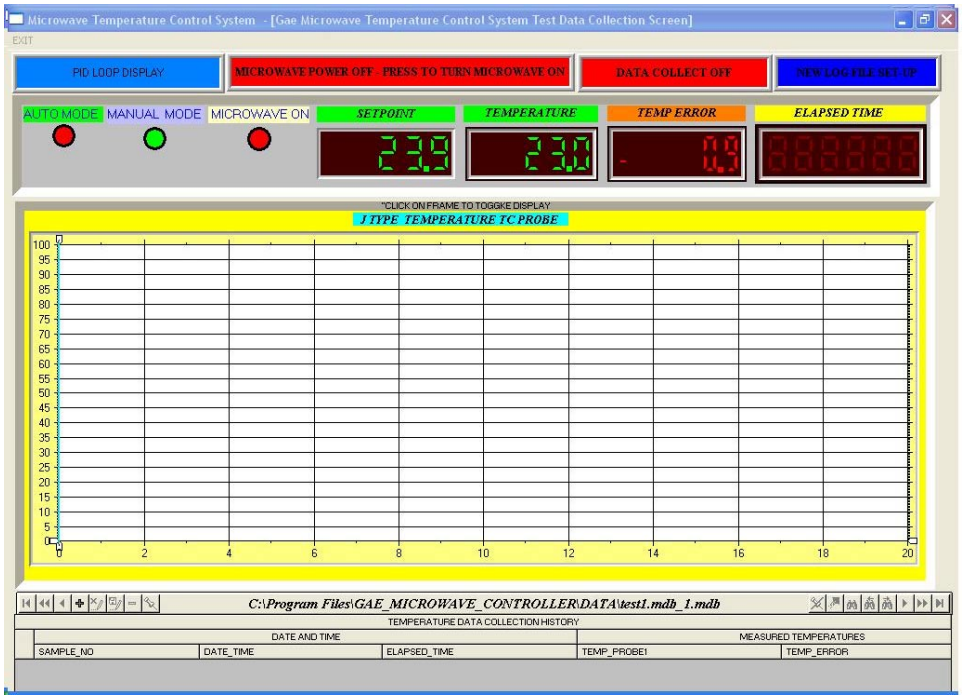

Figure 15. Data collection screen.

Automatic and Manual Control Modes

While the PID LOOP DISPLAY is showing, the operator can monitor the status of the input and output signals and overall controller performance. Upon initially turning on microwave power, the PID loop will be in “automatic” mode which controls the output signal according the PID loop parameter settings and relationship between the temperature signal and setpoint value. This mode will be indicated in two ways:

- The AUTO MODE radio button will be green and the MANUAL MODE button will be red, and
- The bar just below the digital value indicators will be green and read PID LOOP – AUTOMATIC MODE.

Clicking on the PID LOOP – AUTOMATIC MODE bar (Figure 16) will change the controls to “manual” mode as indicated by the AUTO and MANUAL radio buttons will reverse colors and bar will change to blue and read PID LOOP – MANUAL MODE. In this

mode the operator can manually adjust microwave output power by sliding (left-click and hold) the OUTPUT slider indicator up or down.

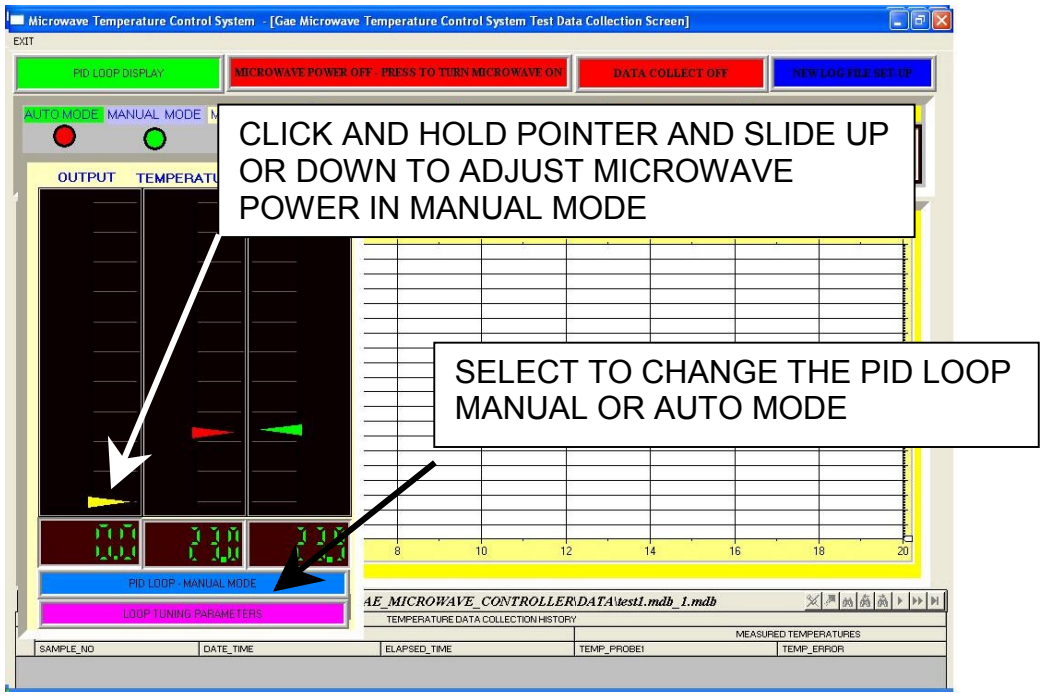
Microwave Temperature Control System - [Gae Microwave Temperature Control System Test Data Collection Screen]
EXIT
PID LOOP DISPLAY
MICROWAVE POWER OFF - PRESS TO TURN MICROWAVE ON
DATA COLLECT OFF
NEW LOG FILE SET UP
AUTO MODE
MANUAL MODE
OUTPUT
CLICK AND HOLD POINTER AND SLIDE UP OR DOWN TO ADJUST MICROWAVE POWER IN MANUAL MODE
SELECT TO CHANGE THE PID LOOP MANUAL OR AUTO MODE
PID LOOP - MANUAL MODE
LOOP TUNING PARAMETERS
AE_MICROWAVE_CONTROLLER\DATA\test1.mdb_1.mdb
TEMPERATURE DATA COLLECTION HISTORY
MEASURED TEMPERATURES
SAMPLE_NO
DATE_TIME
ELAPSED_TIME
TEMP_PROBE1
TEMP_ERROR

Figure 16. Data Collection Screen after the PID loop screen has been selected.

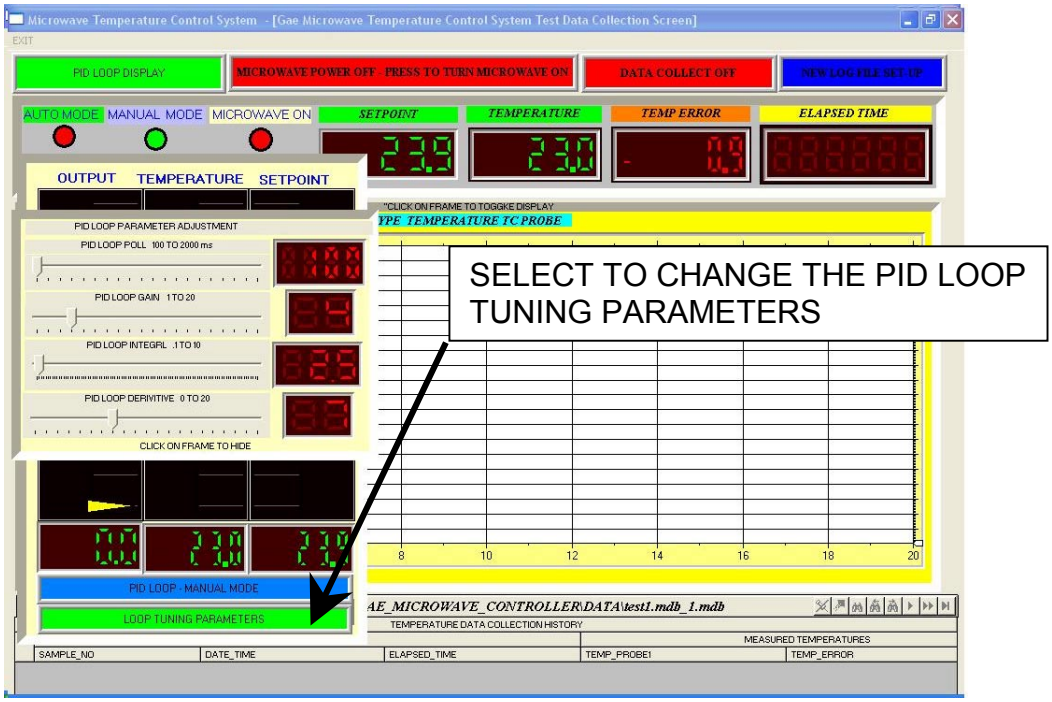

Figure 17. Data Collection Screen with the PID loop tuning screen displayed.

PID Loop Parameters

Clicking on the LOOP TUNING PARAMETERS bar (Figure 17) displays the PID loop parameter controls and indicators. Adjust each parameter by moving (left-click and hold) the respective slider while observing the indicated value.

Data Statistics

Clicking anywhere on the chart will display the statistical values for the data being collected (Figure 18). Move the vertical red line to the position on the chart for display of specific data values.

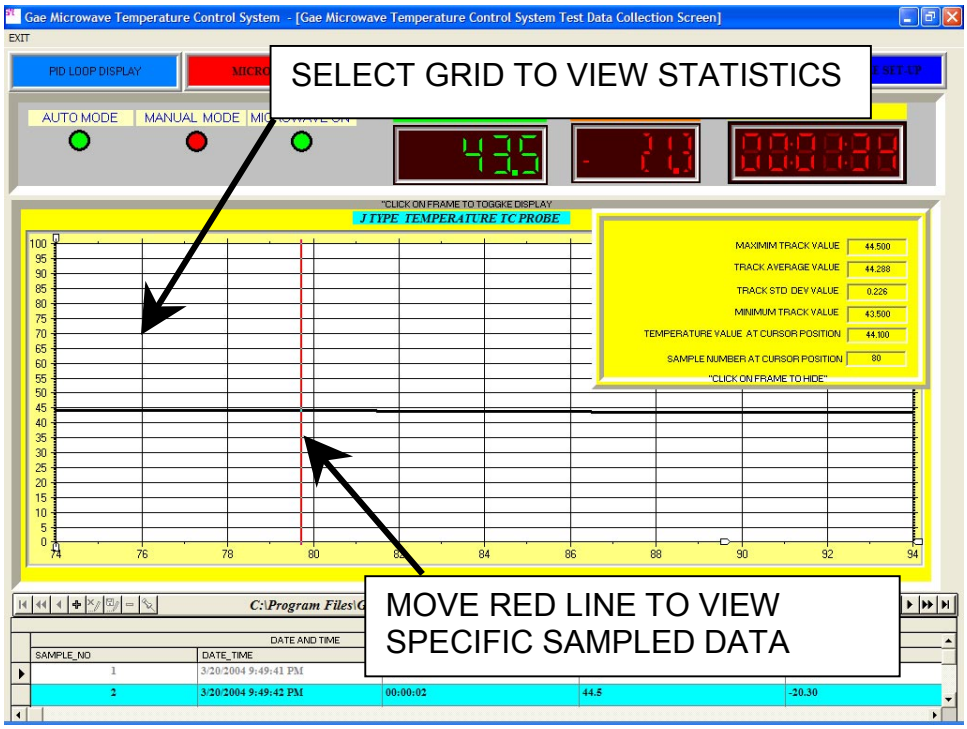
Gae Microwave Temperature Control System - [Gae Microwave Temperature Control System Test Data Collection Screen]
EXIT
PID LOOP DISPLAY
AUTO MODE
MANUAL MODE
SELECT GRID TO VIEW STATISTICS
"CLICK ON FRAME TO TOGGKE DISPLAY
J TYPE TEMPERATURE TC PROBE
MAXIMIM TRACK VALUE
TRACK AVERAGE VALUE
TRACK STD DEV VALUE
MINIMUM TRACK VALUE
TEMPERATURE VALUE AT CURSOR POSITION
SAMPLE NUMBER AT CURSOR POSITION
"CLICK ON FRAME TO HIDE"
MOVE RED LINE TO VIEW SPECIFIC SAMPLED DATA
DATE AND TIME
SAMPLE_NO
DATE_TIME

Figure 18. Data Collection Screen with statistics displayed.

Recalling Previous Data

The data collected during previous sessions can be displayed on the Data Collection Screen. Use the following procedure to recall an existing data file.

1. To open an existing data file, click the DIRECTORY FILE SELECTOR bar in the data file selection screen (Figure 19).

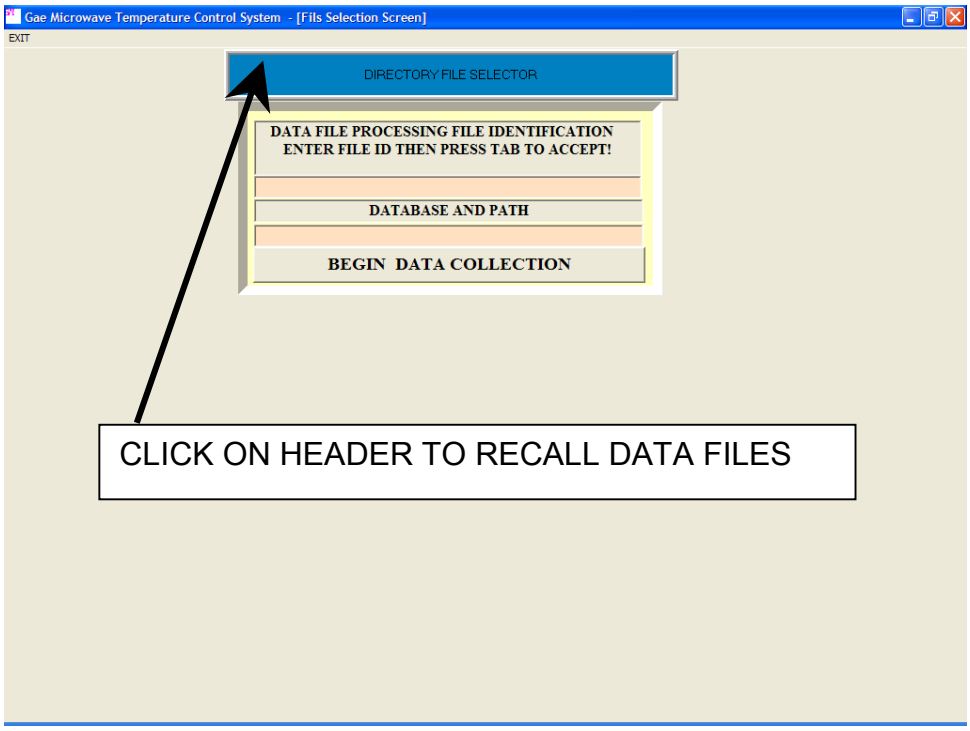
Gae Microwave Temperature Control System - [Fils Selection Screen]
EXIT
DIRECTORY FILE SELECTOR
DATA FILE PROCESSING FILE IDENTIFICATION
ENTER FILE ID THEN PRESS TAB TO ACCEPT!
DATABASE AND PATH
BEGIN DATA COLLECTION
CLICK ON HEADER TO RECALL DATA FILES

Figure 19. Data file set-up screen.

2. The file directory (folder) where data files are stored will appear (Figure 20. Select the desired file by *double-clicking* on the file name.
3. The selected file will then be displayed in File Selection Screen (Figure 19). Click on the CLICK TO BEGIN DATA COLLECTION bar.
4. The Duplicate File Name dialog box will then appear (Figure 21). Select “No” to indicate that you want to use the name shown.
5. The Change File Name dialog box (Figure 22) will then appear. Select “No” again to indicate that you wish to display the existing file information.
6. If the Exit Program Critical Error dialog box appears (Figure 23), ignore it by clicking either “OK” or “Cancel”.

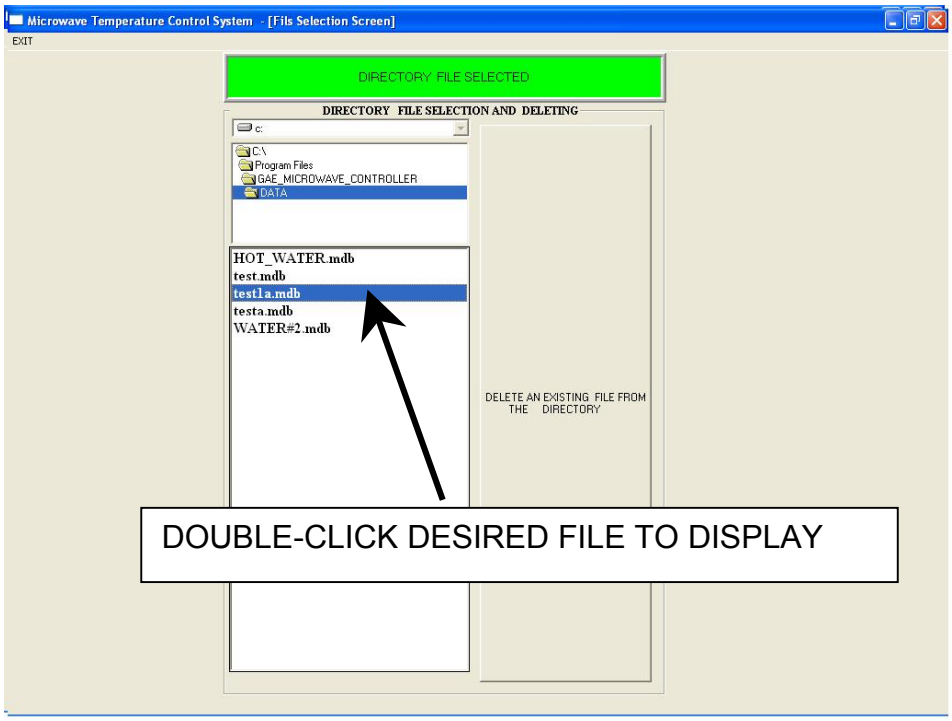

Figure 20. Set-up screen for selecting existing data file.

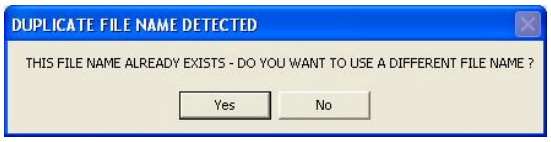

Figure 21. Duplicate File Name Detected dialog box.

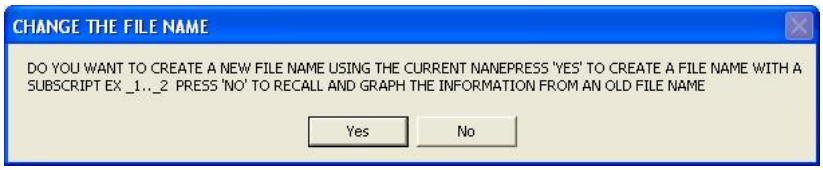
CHANGE THE FILE NAME
DO YOU WANT TO CREATE A NEW FILE NAME USING THE CURRENT NANEPRESS 'YES' TO CREATE A FILE NAME WITH A SUBSCRIPT EX _1.._2 PRESS 'NO' TO RECALL AND GRAPH THE INFORMATION FROM AN OLD FILE NAME
Yes
No

Figure 22. Change File Name dialog box.

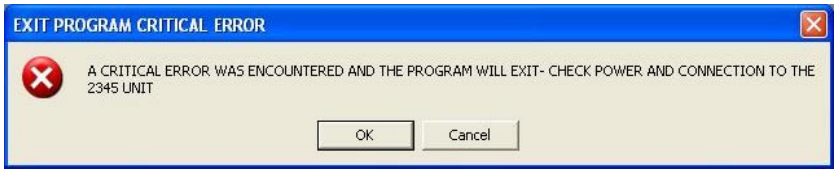
EXIT PROGRAM CRITICAL ERROR
A CRITICAL ERROR WAS ENCOUNTERED AND THE PROGRAM WILL EXIT- CHECK POWER AND CONNECTION TO THE 2345 UNIT
OK
Cancel

Figure 23. Exit Program Critical Error dialog box to be ignored.

The entire history of the recalled data will now be displayed in the Data Collection Screen. Note that the control buttons will appear to be active as they will change color and message clicked. However, the control functionality of these buttons has been disabled while viewing existing data files.

To exit the program from this screen, click the normal Windows “Close” button in the upper right corner of the window.

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MAINTENANCE AND CALIBRATION

The Process Control System (PCS) is designed to be maintenance free and does not contain any consumable components. No calibration is necessary except for that of the thermocouples provided by the customer and used with the PCS.

However, the PCS can be subject to damage due to improper operating conditions or mishandling. If damage occurs, the system should be returned to GAE for repair. Contact GAE for information on repair services.

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